Section 7.2
Underdrained Bioretention Cell BMP

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7.2.1 Description

A bioretention cell is a type of underdrained soil filter designed to collect, infiltrate/filter, and treat moderate amounts of stormwater runoff using conditioned planting soil beds, gravel underdrained beds and vegetation within shallow depressions. The major difference between an underdrained grassed soil filter and a bioretention cell is the vegetation. A typical grassed underdrained soil filter may be planted with grass, whereas a bioretention cell is planted with a variety of shrubs and perennials whose roots assist with the passing of water and uptake of pollutants. Studies have shown that bioretention cells are capable of reducing sediment, nutrients, oil and grease, and trace metals.

Like grassed filters, bioretention cells control stormwater quality by capturing and retaining runoff and passing it through a filter bed comprised of a specific soil media. Once through the soil media, the runoff is collected in a perforated underdrain pipe and discharged downstream. The filter structure provides for the slow release of smaller storm events, minimizing stream channel erosion, and cooling the discharge. Bioretention cells are usually located in close proximity to the origin of the stormwater runoff and should be scattered throughout a residential area or along the downhill edge of smaller parking areas.

Bioretention cells with an underdrained soil filter must detain a runoff volume equal to the sum of 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area. This surface area of a bioretention cell should represent no less than the sum of 7% of the impervious area and 3% of the landscaped area draining into it, with other upgradient areas directed away from the basin.

When used to meet the phosphorus allocation in lake watersheds, the sizing of the underdrain filter structure needs to be adjusted in accordance with Volume II of this BMP manual.

The peak storage depth of the channel protection volume within a bioretention cell structure may not exceed 6 inches and should be designed to drain dry within 24 to 48 hours. Storage and detention for flooding conditions is not allowed within the structure and over the channel protection volume because of the potential impact to the plants in the basin. An independent structure must be provided.

The basin must be planted with plant species that are tolerant of draught and wet conditions. Full plant cover must be achieved within the first year following construction.

Figures 7.3 and 7.4 show two pipe bedding options for constructing bioretention cell meeting DEP's criteria.

7.2.2 Site Suitability Criteria

Drainage Area: The size of the basin and storage capacity over the filter is based on the size and land use within the area draining to the structure. Areas not needing treatment should be diverted away from a biocells.

Depth to Groundwater: In most instances, the bottom of the filter should be above the seasonal high groundwater table.

Test Pits: One test pit shall be excavated in the area of the filter bed to identify the depth to groundwater and bedrock.

Bedrock: If bedrock is close to the surface, an impermeable liner may be required to prevent rapid injection and contamination of the groundwater within fractures in the bedrock. If the basin does not have one foot of soil overburden between bedrock and the bottom of the underdrain layer, the basin must be lined with an impermeable geomembrane (not with clay).

Permeable Soils: If a system is located in an area where the soil is highly permeable (i.e. Soil Group A and some Soil Group B soils), the filter basin will *not* need a liner and will *not* need to be designed as an infiltration system per the requirements of Chapter 6 of this manual if the developed area draining to it:

- Contains less than one acre of imperious area.
- Consists only of roof.
- Is a single family residential subdivision, or
- Is not a facility that has a high turnover parking, that stocks hazardous products or that provides industrial or vehicle services and maintenance.

7.2.3 General Design Criteria

The following design criteria apply to all underdrained bioretention cells.

Treatment Volume: A bioretention cell soil filter must detain and filter a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area. Other upgradient areas should be directed away from the filter basin.

Filter Area: The area of the filter (surface area of the filter) must be no less than the sum of 7% of the impervious area and 3% of the landscaped area draining to the filter.

Basin Size: The size of a filter bed should never exceed 2000 sq. ft in basin bottom area or have more than one acre of subwatershed draining to the structure. Larger sizes are difficult to construct and maintain.

Construction Components: Underdrained filters are constructed in excavated holes that are at least three feet deep and consist of, from bottom up:

- A geotextile fabric between natural soils and constructed media. An impermeable membrane may be required if groundwater contamination is a concern.
- A 12 to 14 inch base of coarse clean stone or coarse gravel in which a 4 to 6 inch perforated underdrain pipe system is bedded.
- 18-inch layers of uncompacted soil filter media.
- A selection of plants and 2-3 inches of wood mulch.
- Depression for surface stormwater storage

Impoundment Depth: The peak water quality storage depth may not exceed 6 inches over plants that will sustain frequent draught and inundation that must drain dry in no less than 24 and no more than 48 hours. Due to the deeper root zones of the plants and increased evapotranspiration potential, one third of the soil filter volume may be included as storage volume when designing bioretention cells. Storage over the treatment volume to control peak flows for the flooding standards can not be provided because of potential damage to the vegetation. The overflow outlet must be no more than 6 inches above the filter bottom.

Outlet: The channel protection volume must be discharged solely through the underdrained filter bed with a network of underdrain pipe having a single outlet with a diameter no greater than six inches. Each underdrain system must discharge to an area capable of withstanding concentrated flows and saturated conditions without eroding.

Sediment Pretreatment: Pretreatment devices such as grassed swales, grass or meadow filter strips and sediment traps shall be provided to minimize the discharge of sediment to the underdrained soil filter.

Access: Where needed, a maintenance access shall be planned for and maintained that is at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%. This

access should never cross the emergency spillway, unless the spillway has been designed for that purpose. An easement for long-term access may be needed.

7.2.4 Specific Design Criteria

Underdrain Pipe: Proper layout of the pipe underdrain system is necessary to effectively drain the entire filter area and the slope of the installed underdrain pipe must be positive. There must be at least one line of underdrain pipe for every eight feet of filter area's width. The underdrain piping should be 4" to 6" slotted, rigid schedule 40 PVC or SDR35. Structure joints shall be sealed so that they are watertight. Underdrain pipes must be placed no further than 8 feet apart.

Pipe Bedding: The 4 to 6 inch diameter perforated underdrain pipe(s) must be bedded in 12 to 14 inches of underdrain material with at least 4 inches of material beneath the pipe and 4 inches above. The underdrain material consists of well graded, clean, coarse gravel meeting the MEDOT specification 703.22 Underdrain Type B for Underdrain Backfill (see Table 7.1). The material must contain less than 5% fines passing the #200 sieve.

Soil Filter Bed: The soil filter must be at least 18 inches deep on top of the gravel underdrain pipe bedding and must extend across the bottom of the entire filter area. This soil mixture shall be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No other materials or substances that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations can be mixed within the filter.

Soil Filter Media: Soil media must consist of a silty sand soil or soil mixture combined with 20% to 25% by volume (no less than 10% by dry weight) of a moderately fine shredded bark or wood fiber mulch. Other organic sources must be approved by the department; however an agricultural source is not acceptable for the organic component of the media.

The resulting mixture must have no less than 8% passing the 200 sieve and shall have a clay content of less than 2%. The system must be designed to drain the surface storage volume in no less than 24 hours and no more than 48 hours.

TABLE 7.1 Maine DOT Specifications for Underdrains (MEDOT #703.22)

Sieve Size	% by Weight
UNDERDRAIN - TYPE B	
1”	90-100
½”	75-100
#4	50-100
#20	15-80
#50	0-15
#200	0-5
UNDERDRAIN - TYPE C	
1”	100
¾”	90-100
3/8”	0-75
#4	0-25
#10	0-5

TABLE 7.2 Maine DOT Specifications for Aggregate (MEDOT #703.01)

Sieve Size	% by Weight
3/8”	100
#4	95-100
#8	80-100
#16	50-85
#30	25-60
#60	10-30
#100	2-10
#200	0-5

As an example, the mixture may contain by volume the following:

- *50% of sand (MEDOT #703.01 contains insufficient fine for the media and must be amended)*
- *20% of loamy topsoil*
- *30 % of composted woody fibers and fine shredded bark, superhumus or equivalent*

Clay Content: Use of soils with more than 2 % clay content could cause failure of the system and care should be taken, especially in areas where the predominant soil contains marine clay, that the sand and topsoil used in the mixture have very little or no clay content.

Filter Permeability: The filter must be permeable enough to insure drainage within 48 hours maximum, yet have sufficient fines to insure filtration of fine particles and removal of dissolved pollutants. The design may either rely on the soil permeability, if known, to provide the slow release of the water treatment volume over a minimum of 24 hours, or may insure this rate by installing a constrictive orifice or valve on the underdrain outlet. In determining the permeability of the media, the percent fines of the mixture and the level of compaction should be considered. Generally, the soil media should be only lightly compacted between 90 and 92% standard proctor (ASTM D698) and shall have a permeability of 2.4 in/hr to 4 in/hr.

Gradation testing: Gradation tests, including hydrometer testing for clay content, and permeability testing of the soil filter material, shall be performed by a qualified soil testing laboratory and submitted to the project engineer for review before placement and compaction.

Geotextile Fabric: A geotextile fabric with suitable characteristics may be placed between the sides of the filter layer and adjacent soil. The fabric will prevent the surrounding soil from migrating into and clogging the filter and clogging the outlet. Overlap seams must be a minimum of 12 inches. Do not wrap fabric over the top of the pipe bedding as it will cause clogging and will prevent flows out of the filter. The geotextile fabric shall be Mirafi 170n or equivalent.

Plant Species: The soil filter surface must be planted with plants that are tolerant of well drained soils and frequent inundation. Native plants should be chosen for their tolerance to urban runoff, pollutant loading, temperature and pH. A list of appropriate plant species has been provided in Appendix B of Volume I. A landscape designer or architect should be involved to select the appropriate plants for site conditions. Beware of invasive plant species. Upon planting, the soil filter shall be mulched with but must not be fertilized.

Mulch: Individual planting shall be mulched with 2-3 inches of cover. Acceptable mulch must be well aged, uniform in color, and free of foreign material including plant root material.

Rock Forebay: A rock forebay is recommended to reduce flow velocity into the basin. It shall remain clear of sediment until the upgradient tributary area is fully vegetated.

7.2.5 Construction Criteria

Construction Sequence: Erosion and sedimentation from unstable subcatchments is the most common reason for filter failure. Not heeding the construction sequencing criteria is likely to result in the need to replace the soil filter. The soil filter media and vegetation must not be installed until the area that drains to the filter has been permanently stabilized with pavement or other structure, 90% vegetation cover, or other permanent stabilization. Otherwise, the runoff from the contributing drainage area must be diverted around the filter until stabilization is completed unless the Department has determined, on a case-by-case basis that sufficient measures are being taken to prevent erosion of material from the unstable catchment area and deposition on the filter.

Basin excavation: The area of the basin may be excavated in preparation of the installation of the underdrain and can be used for a sediment trap from the site during construction. After excavation of the basin, the outlet structure and piping system must be installed at the appropriate elevation and protected with a sediment barrier. If the basin is to be used as a sediment trap, the sides of

the embankments must be mulched and maintained to prevent erosion.

Compaction of soil filter: Filter soil media and underdrain bedding material must be compacted to between 90 and 92% standard proctor. The bed should be installed in at least 2 lifts of 9 inches to prevent pockets of loose media.

Outlet Discharge: The Overflow of the filter basin shall be placed no more than 6 inches above the filter media. The outlet of the underdrain must discharge to an area that is stable to prevent erosion.

Remedial Cover: If sedimentation has occurred within the first year, the organic mulch must be removed and replaced with a fresh a 2-3 inch layer of fresh mulch.

Construction Oversight: Inspection of the filter basin shall be provided for each phase of construction by the design engineer with required reporting to the DEP. At a minimum, inspections will occur:

- For all material used for the construction of the filter basin will be approved by the design engineer after tests by a certified laboratory show that they are passing DEP specifications.
- After preliminary construction of the filter grades and once the underdrain pipes are installed but not backfilled;
- After the drainage layer is constructed and prior to the installation of the filter media;
- After the filter media has been installed, planted and mulched, and
- After one year to inspect health of the vegetation and make corrections.

Testing and Submittals: The contractor shall identify the location of the source of each component of the filter media. All results of field and laboratory testing shall be submitted to the project engineer for confirmation. The contractor shall:

- Submit samples of each type of material to be blended for the mixed filter media and samples of the underdrain bedding material. Samples must be a composite of three different locations (grabs) from the stockpile or pit face. Sample size required will be determined by the testing laboratory.
- Perform a sieve analysis conforming to ASTM C136 (Standard test method for sieve analysis of fine and coarse aggregates; 1996a) on each type of the sample material. The resulting soil filter media mixture MUST have 8% to 12% by weight passing the #200 sieve, a clay content of less than 2% (determined hydrometer grain size analysis) and have 10% dry weight of organic matter.
- Perform a permeability test on the soil filter media mixture conforming to ASTM D2434 with the mixture compacted to 90-92% of maximum dry density based on ASTM D698.

7.2.6 Maintenance Criteria

During the first year, the basin will be inspected semi-annually and following major storm events.

- Debris and sediment buildup shall be removed from the forebay and basin as needed. Any bare area or erosion rills shall be repaired with new filter media or sandy loam then planted and mulched.
- A healthy plant cover will minimize clogging with fine sediments and if ponding exceeds 48 hours, the filter bed must be rototilled and reestablished.

Maintenance Agreement: A legal entity should be established with responsibility for inspecting and maintaining any biocells. The legal agreement should establish the entity, list all specific maintenance responsibilities (including timetables) and provide for the funding to cover long-term inspection and maintenance.

Filter Inspection: The soil filter should be inspected after every major storm in the first year to be sure it is functioning properly and that the plants are establishing. Thereafter, the filter should be inspected at least once every six months to ensure that it is draining within 48 hours following a one inch storm or greater.

Soil Filter Replacement: The mulch shall be replaced with fresh material on a yearly basis.

Sediment Removal: Sediment and plant debris should be removed from the pretreatment structure at least annually. Removed sediments should be disposed of in an acceptable manner.

Fertilization: Fertilization of the underdrained filter area should be avoided unless absolutely necessary to establish vegetation.

Harvesting and Weeding: Harvesting and pruning of excessive growth will need to be done occasionally. Weeding to control unwanted or invasive plants may also be necessary. Plants that are not thriving must be replaced.